

ANSWERS: Explaining Polarity of molecules

Key points to consider for an Excellence grade are...

Does the molecule

- 1) contain polar bond(s), you must refer to a difference in electronegativity between the relevant atoms
- 2) have lone pair(s) around the central atom
- 3) have a symmetrical shape
- 4) whether the polar covalent bonds (aka dipoles) cancel

The **CBr₄** molecule is non-polar.

The **CH₃Br** molecule is polar.

Both CBr₄ and CH₃Br have four regions of electrons around the central carbon atom. These are all bonding electron regions (clouds) so the shape of both molecules is tetrahedral.

The C-Br bond is polar due to the difference in electronegativity between C and Br.

In CH₃Br, the C-Br bonds are more polar than the C-H bond as the electronegativity of the Br is greater than the electronegativity of the C and H. Although the bonds are arranged symmetrically around the carbon atom, the lower polarity of the C-H bond means that the bond dipoles do not cancel so the molecule is polar.

In CBr₄, all bonds are polar and are the same (C-Br). The bonds are arranged symmetrically around the central C atom and because the bond dipoles cancel, the molecule is non-polar

(In **CCl₄**, the C-Cl bonds are polar, due to differences in electronegativity of C and Cl atoms. However, four C-Cl bonds are arranged symmetrically in a tetrahedral shape (with 4 bonding regions and no lone pairs around the central atoms) and the charges are spread evenly, resulting in a non-polar molecule.)

The C-Cl bond is polar due to the difference in electronegativity between C and Cl. The C-Cl bonds are more polar than the C-H bond as the electronegativity of Cl is greater than the electronegativity of C and H. The bonds are arranged symmetrically in tetrahedral positions around the C atom.

CHCl₃ and CH₂Cl₂ have four regions of electron density around the central C atom. These are all bonding pairs of electrons so the shape of both molecules is tetrahedral.

Because the bonds are arranged in tetrahedral positions and the C-Cl bonds are polar, both **CHCl₃** and **CH₂Cl₂** are polar molecules.

In **H₂S**, the polar bonds are arranged

asymmetrically around the central atom in a bent shape as there are two lone pairs of electrons on the central atom. The bond dipoles do not cancel so the molecule is polar.

CO₂ has non-polar molecules. The C-O bonds of CO₂ are polar due to the differing electronegativities of C and O atoms. However, as there are only 2 electron repulsions about the central C atom (2 bonding regions and no lone pairs), the polar bonds are symmetrical about the C atom with a linear shape, and the effect of these polar bonds/bond dipoles is cancelled, so that the molecule is nonpolar.

Non-polar molecules arise when there are no polar bonds present in the molecule or the spread of charge is even. Molecules are polar if there is an uneven spread of charge over the molecule.

In **CH₃Cl**, the polarity of the C-H bonds and the C-Cl bonds are different; due to differences in electronegativity between the C and Cl atoms (the C-Cl bonds are more polar). There are 4 bonding regions of electron repulsion around the central C atom (with no lone pairs). Because of the higher electronegativity of the Cl atom, the charges are not spread evenly around the central C atom /the dipoles do not cancel, and the molecule is polar overall.

In **NH₃**, the N-H bonds are polar due to differences in electronegativity /dipoles of N and H atoms. The three polar N-H bonds are not spread symmetrically around the trigonal pyramid shaped molecule, due to the lone pair of electrons (there are 4 regions of electron density around the central N atom, 3 of these are bonding regions and 1 is a lone pair), the bond dipoles do not cancel, therefore the molecule is polar.

The molecule **CF₄** has 4 electron repulsions around the central C atom, which are all bonding sets, so the shape is tetrahedral. The C-F bond is polar due to the difference in electronegativity between C and F. The polar bonds are arranged symmetrically around the central atom, so the bond dipoles cancel and the molecule is non-polar.

The **Cl₂O (or OCl₂)** molecule has 4 electron repulsions around the central atom, which gives the molecule a basic tetrahedral shape. Two are bonding sets and two are non-bonding sets, so the molecule has a bent shape. Cl₂O also contains polar bonds.

The bonds are polar as the atoms in the bonds have different electronegativity values. In Cl₂O, the polar bonds are arranged asymmetrically around the central atom in a bent shape as there are two lone pair of electrons on the central atom. The bond dipoles do not cancel and the molecule is polar.

The **COCl₂** molecule has 3 areas of electron repulsion around the central C atom, so the shape is trigonal planar. Both C-Cl bonds are polar, due to the difference in electronegativity of C and Cl. The C=O bond is also polar, due to the difference in electronegativity of C and O.

Even though the shape is trigonal planar, the molecule is asymmetrical, as the electronegativity difference of the three bonds is not the same. Therefore the effects of these polar bonds are not cancelled and the molecule is polar overall.

SiH₄ is non-polar, The Si-H bonds are polar, because of differing electronegativities of Si and H. However, as there are 4 electron repulsions around the central Si atom, the polar bonds are arranged symmetrically around the central atom / tetrahedral shape. The net effect is that the bond dipoles cancel, therefore the molecule is non-polar.

SO₂ has polar molecules. The S-O bonds of SO₂ are polar due to the differing electronegativities of S and O. There are 3 electron repulsions about the central S atom (trigonal planar), however, the lone pair of electrons on the S atom causes the S-O bonds to occupy a bent or V shape around the central S. Therefore the effect of these polar bonds /bond dipoles is not cancelled, so that the molecule is polar.

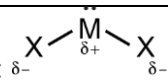
The N-Cl bond in **NCl₃** is polar due to the difference in electronegativity of Cl and N atoms. The trigonal pyramid arrangement of the three N-Cl bonds around the N atom is asymmetrical. The lone pair of electrons on the N atom causes the asymmetry. The effect of the polar bonds is not cancelled, making the molecule polar.

1) Polar: bent

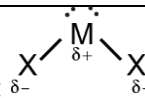
Non-polar: linear

If MX₂ is polar, this indicates that the polar M-X bonds are not spread symmetrically around the central M atom. There must be either three or four regions of negative charge with only two bonded atoms therefore the shape must be bent.

Three regions of negative charge: δ^-



Four regions of negative charge: δ^-



If MX₂ is non-polar this means that the polar M-X bonds are spread symmetrically around the central M atom. There must be only two regions of negative charge around the M atom, both bonded by X atoms in a linear shape.

Two regions of negative charge:

